Performance of pulse species in central and southern NSW – 2021 to 2023

Rohan Brill[1], Liz Farquharson[2], Graeme Sandral[3], Michael Moodie[4], Maurie Street[5], Ben O'Brien[5], Tom Price[6], Barry Haskins[7] & Rachael Whitworth[7]

[1] Brill Ag
[2] SARDI
[3] formerly GRDC
[4] Frontier Farming
[5] Grain Orana Alliance
[6] FAR Australia
[7] AgGrow Agronomy

Key words

faba bean, chickpea, vetch, field pea, lupin, lentil, nitrogen fixation, grain nitrogen, pulse, yield

GRDC code

BRA2105-001RTX

Take home message

- In 2021-2023 trials, for each tonne of shoot biomass (above ~0.7 t/ha), total nitrogen fixation averaged 28 kg/ha
- The average fixed nitrogen remaining after grain harvest (nitrogen balance) was 17 kg/ha for each tonne of shoot biomass (above ~1.7 t/ha)
- Grain nitrogen concentration ranged from 5.5% in lupins, down to 3.2% in chickpea. Nitrogen removal per tonne of grain harvested was ranked from albus lupin > narrow-leaf lupin > vetch > lentil = faba bean = field pea > chickpea
- Faba beans were the highest yielding species on average (2.6 t/ha) but had the largest variability in yield. Field peas were the second highest yielding species (2.1 t/ha), with lower variability in yield than faba beans.
- Gross income (grain value + residual nitrogen value) was highest in faba beans (on average), but there was a general trend that species with high average income (faba beans and lupins) had high variability. Field peas had the lowest average income, but the lowest variability.

Introduction

In 2021 GRDC initiated a project focused on 'Best Practice Pulse Agronomy' that brought together a unique group of organisations including Frontier Farming, Grain Orana Alliance, FAR Australia and AgGrow Agronomy. Led by Brill Ag it established two major themes of pulse crop research activity:

1. Maximising economic yield and nitrogen (N) fixation in regional environments.
2. Developing locally relevant research knowledge on limitations to pulse production and productivity. Research to date has focused on plant density, disease management, nutrition management, inoculation strategy, phenological development, and herbicide tolerance.

This paper reports on the findings from Theme 1 above for the 2021 to 2023 seasons.

Materials and methods

Trials were conducted at 19 sites across southern and central NSW from 2021 to 2023 (Table 1). Sites were selected to be regionally relevant with challenges (both perceived and real e.g., low pH, sodic

and/or poorly drained soils) that may restrict the inclusion and production of pulses in the rotation. The research is not designed to compare the performance of pulses in a benign situation but is focused more on determining the performance of pulse species for yield and N fixation in the local environment where adapted species may thrive, but less adapted species may struggle.

Table 1. Site description of pulse agronomy research sites from 2021 to 2023

Site	Sowing date	Rain (mm)		pH (Ca) 0–10 cm	Available N (kg/ha)	Site description
		Jan-Mar	Apr-Nov			
2021						
Barellan	13 May	270	435	4.5	63 (0–60 cm)	Acidic sandy loam soil.
Buraja	7 May	180	450	4.6	54 (0–10 cm)	Moderately acidic silty loam soil
Canowindra.	3 May + 20 May[1]	290	490	4.8	192 (0–120 cm)	Moderately acidic, well drained red loam soil
Caragabal.	29 April + 18 May[1]	280	480	5.0	53 (0–60 cm)	Slightly acidic loam with subsoil sodicity
Ganmain	28 April + 18 May[1]	220	360	5.3	82 (0–60 cm)	Slightly acidic loam soil with subsoil sodicity
Gol.Gol	31 May	0	114	7.7	85 (0-120 cm)	Alkaline sandy loam
Parkes	31 May	290	485	5.7	126 (0–90 cm)	Neutral pH, moderately heavy soil type with subsoil sodicity
2022						
Barellan	6 May	255	537	5.2	76 (0–60 cm)	Well drained sandy loam soil
Ganmain	9 May	185	572	5.5	115 (0–80 cm)	Generally well drained loam soil but site was very wet in 2022.
Trundle	28 June	155	705	5.6	103 (0–90 cm)	Generally well drained loam soil but site was very wet in 2022.
Wellington	23 May	235	780	5.4	120 (0–60 cm)	Grey basalt soil, wet in 2022.
Wentworth	12 May	20	390	8.1	42 (0-120 cm)	Alkaline sandy soil type
2023						
Arumpo	14 April + 27 April + 15 May[3]	52	200	7.5	69 (0-100 cm)	Alkaline sandy loam soil
Barellan	9 May	124	168	4.9	54 (0-60 cm)	Well drained sandy loam soil
Caragabal	19 April + 19 May[2]	195	185	5.9	110 (0-100 cm)	Well drained loam soil
Daysdale	3 May	99	257	4.9	85 (0-100 cm)	Well drained acidic loam soil
Dunedoo	10 May + 10 June[1]	171	184	5.2	112 (0-60 cm)	Well drained loam soil
Ganmain	5 May + 24 May[3]	125	185	5.9	87 (0-100 cm)	Clay loam topsoil with sodic subsoil
Trangie	9 May	120	152	4.7	93 (0-90 cm)	Well drained acidic loam soil

[1] Faba beans, vetch and lupins sown at earlier sowing date; field peas, lentils and chickpeas sown at later sowing date.
[2] Faba beans, vetch and lupins sown at both sowing dates; field peas, lentils and chickpeas only at later sowing date
[3] All species sown at all dates

N fixation was determined by collecting biomass samples at peak biomass (mid-podding stage before leaf drop) and analysed using the ^{15}N natural abundance technique (Unkovich *et al*., 2008) to determine what proportion of the N in the biomass was derived from the atmosphere (NDFA). Once the quantity of NDFA in above ground biomass was calculated (peak biomass * N content of biomass * NDFA%), total N fixation (N-fix) was calculated by multiplying by a co-efficient that estimates the root contribution (1.5 for faba beans, field peas, lentils, lupins and vetch; 2.0 for chickpeas. These figures (1.5 and 2.0) are known as 'root factors' and are described by Swan *et al*. (2022). The root factor calculation makes an allowance for below ground N (e.g. in roots and nodules) so an improved estimate of total N fixed can be provided. Finally, the N balance is calculated by subtracting the N removed in grain (grain yield * grain N%) from total N fixed.

Results

Total nitrogen fixation

Total N fixed by the pulse species across the sites was closely related to crop biomass. For each tonne of biomass >0.7 t/ha, total N fixation was ~28 kg N/ha (Figure 1). Some crop biomass figures were very high in 2021 and 2022 due to high rainfall, with biomass >20 t/ha and total nitrogen fixation above 600 kg/ha. However, the 'average' pulse crop grew 6.4 t/ha biomass and fixed 163 kg N/ha.

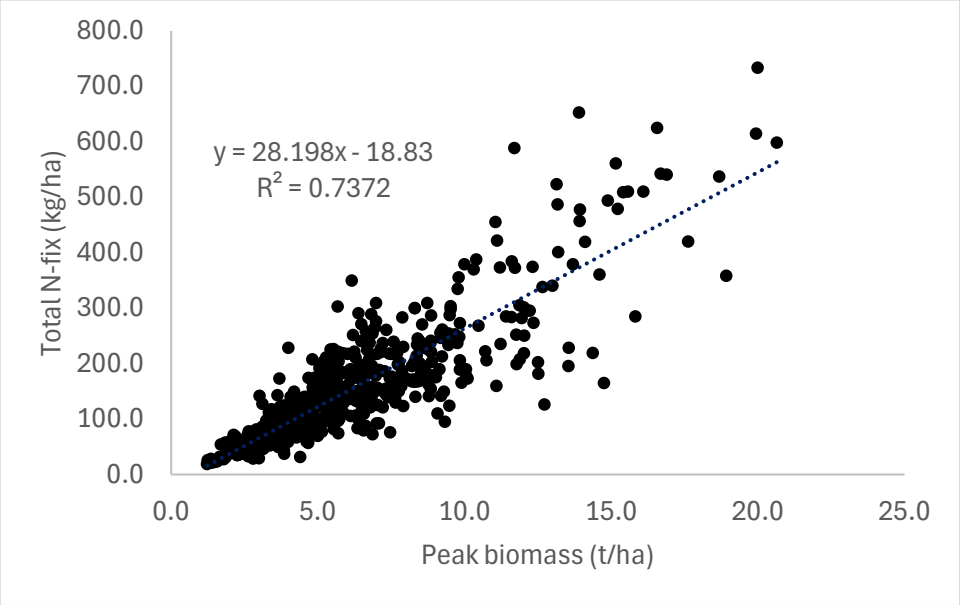

Figure 1. Relationship between peak biomass of pulses and total N fixed (N-fix) in NSW Pulse Agronomy trials from 2021 to 2023.

Nitrogen removal in grain

Nitrogen concentration in the grain was highest in lupin and lowest in chickpea. Within the lupin species (data not shown), albus lupins had N concentration of 60 kg N/tonne, while narrow-leaf lupins had N concentration of 52 kg N/ tonne. Faba beans, field peas and lentils all had grain N concentration from 40–42 kg N/tonne of grain (Figure 2). Vetch hay (from nearby trials) had an average N content of 27 kg N/tonne of hay (data not shown). The grain N concentration of each pulse species was consistent across sites and seasons.

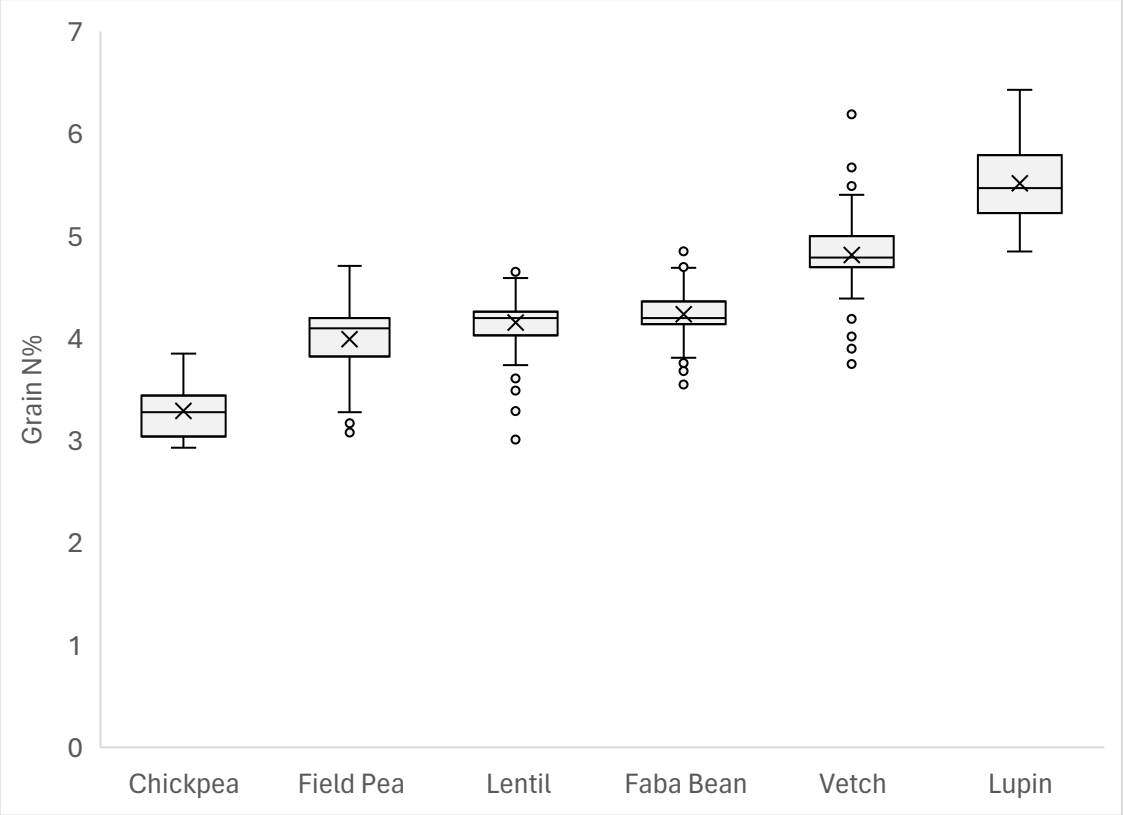

Figure 2. Average grain N concentration of pulse species in trials in southern and central NSW from 2021 to 2023.

Nitrogen fixation and nitrogen balance across species

The median nitrogen fixation of field peas, vetch, lupin and faba beans were all in the range from 150–165 kg N/ha. Chickpeas and lentils were lower at 114 and 84 kg N/ha respectively (Figure 3). Faba beans and lupins had average nitrogen fixation from 185 to 200 kg N/ha, which was well above their median nitrogen fixation as the data was skewed by the very high biomass in some trials in 2021 and 2022.

N balance is a measure of total nitrogen fixation minus nitrogen removed in grain. N balance was positive in 95% of observations. Field peas, vetch and faba beans had a nitrogen balance in the range of 75 to 90 kg/ha. The high N concentration in lupin grain and low N concentration in chickpea grain meant that lupin and chickpea nitrogen balance was similar, despite lupins fixing more nitrogen.

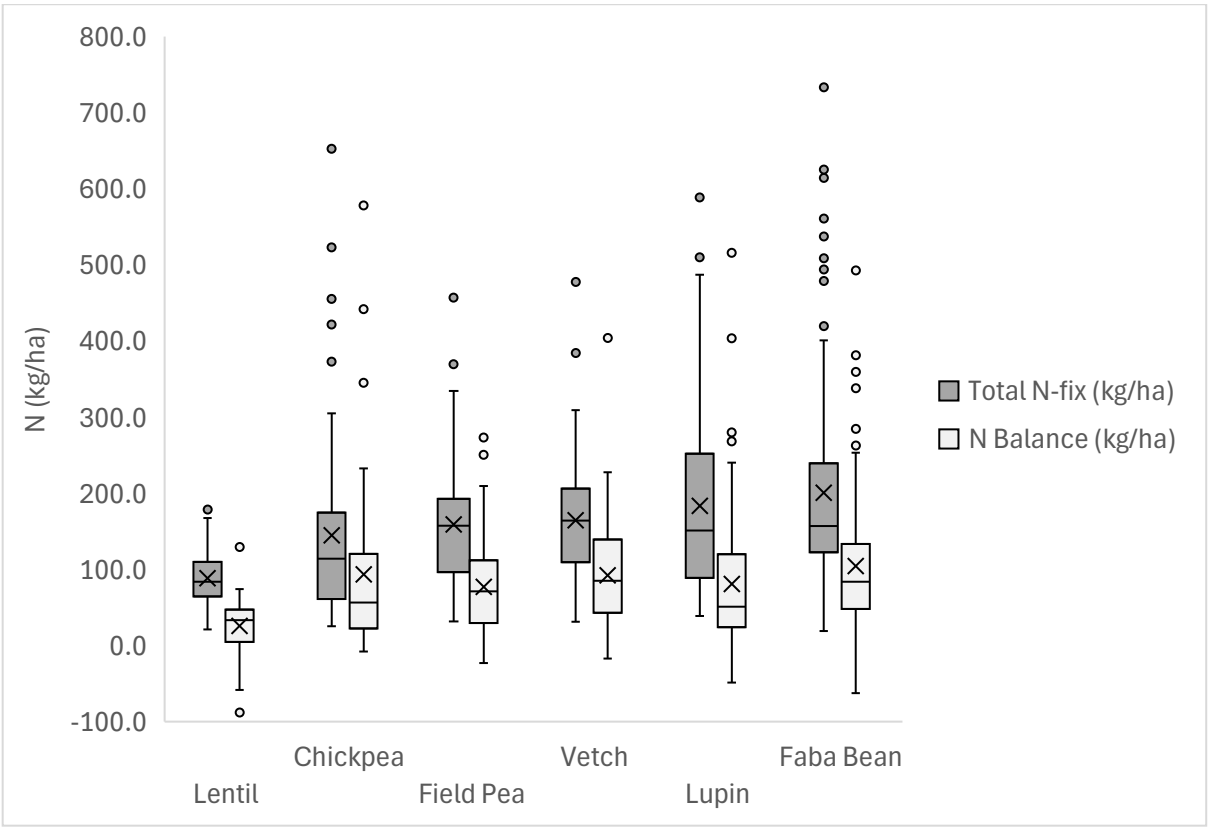

Figure 3. Total nitrogen fixation and nitrogen balance of pulse species from 2021 to 2023 across NSW Pulse Agronomy Trials.

Income from grain and residual nitrogen

Gross income was calculated for each species (vetch not included), adding together the value of grain (yield * assumed price) and value of residual nitrogen (Figure 4). Price assumptions were based on average prices for the 2021–2023 period:

- Chickpeas = $600/tonne
- Faba beans = $420/tonne
- Field peas = $450/tonne
- Lentils = $700/tonne
- Lupins = $500/tonne
- Nitrogen = $1.75/kg

Faba beans had the highest average gross income at $1346/ha but the most variability of any species and a much lower median income of $901/ha. At the other extreme, field peas had low variability with an average of $1050/ha and a median income of $975/ha. Field pea income at the lower quartile (75% of observations above this point) was $752/ha compared with lupins and faba beans which were both around $550/ha at the lower quartile.

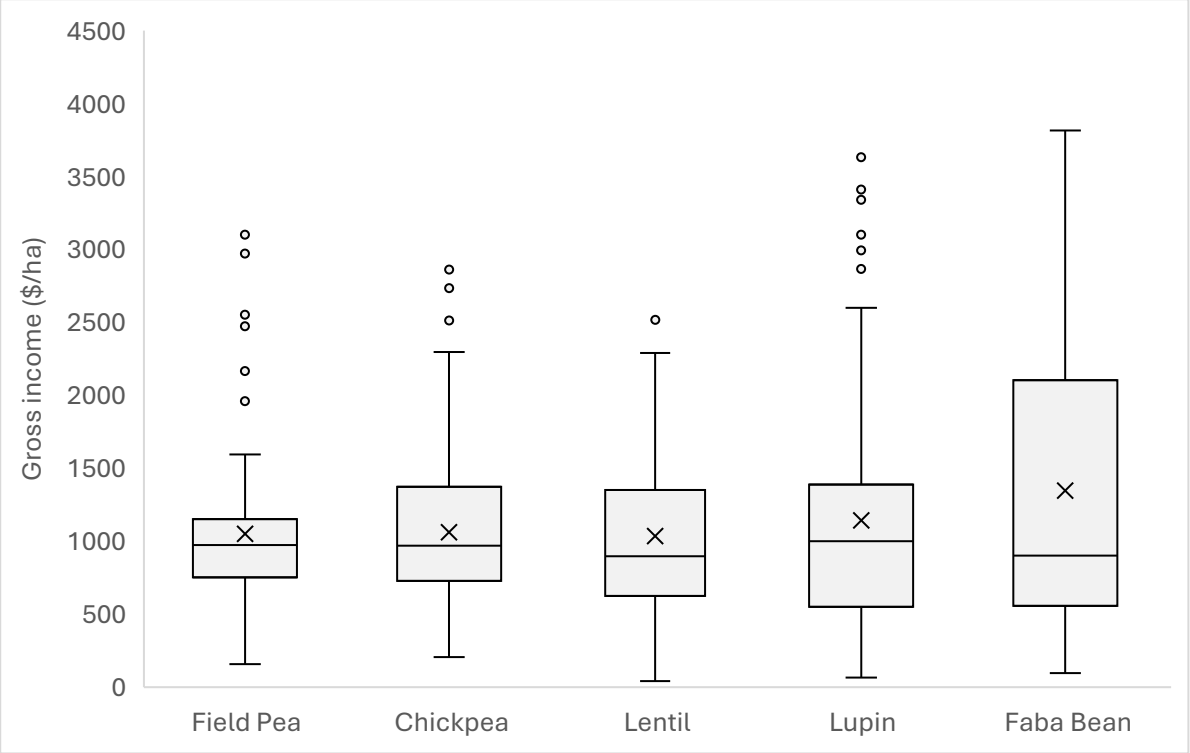

Figure 4. Gross income (grain yield * price) + (residual N * N price) of pulse species in NSW Pulse Agronomy Project from 2021 to 2023.

Discussion and conclusion

Nitrogen fixation in pulses is closely related to crop biomass, with average nitrogen fixation in this project of ~28 kg N/ha per tonne of above ground biomass. There were many instances within the project where total nitrogen fixation exceeded 300 kg N/ha (e.g. faba beans in the wetter seasons of 2021 & 2022), however the average for all pulse crops was 6.4 t/ha biomass and 163 kg N/ha fixed. Practices to maximise biomass and N fixation in pulses include:

- Select high biomass species that are adapted to the local environment (soil type and climate).
- Minimise the effects of soil constraints such as acidity and sodicity.
- Ensure effective pulse nodulation.
- Ensure adequate nutrition is supplied, especially phosphorus.

The value of a pulse crop to a farmer is a combination of income received for grain and value of residual nitrogen. Despite their relatively low price, faba beans were able to generate a very high income (25% of observations were above $2100/ha), but gross income was highly variable. Faba bean yield was average or below average in lower rainfall environments. Field peas on the other hand rarely reached the high values of faba beans, but had consistent income and importantly, the highest income of any species at the lower quartile level. The introduction of the new variety APB Bondi(Þ), makes field peas worth reconsidering for growers in low-medium rainfall environments. The nitrogen fixation value of lentils was the lowest of all species, but its high grain value meant its total income was closer to average.

The economics reported here are obviously sensitive to future changes in the price of pulses and nitrogen. If the price of nitrogen increases relative to the price of pulse grain, the choice of pulse crop

would favour species that fix more N. If the price of N reduces relative to the price of pulse grain, the choice of pulse crop would favour species that have high yield and/or high price.

Individual results from every trial from this project is available at Online Farm Trials (www.farmtrials.com.au/), which is a great resource for applied, local agronomy research. This work couples well with GRDC Farming Systems research to gain a full understanding of the role of pulses in regional farming systems.

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

Thanks to grower co-operators Jeff Savage (Barellan), Dennis Tomlinson (Buraja), Daybreak Farming (Caragabal), Stephen Cooper (Caragabal), Chris Berry (Trundle), Viridis Ag (Canowindra), Angus Maurice (Wellington), Trentham Estate (Gol Gol), Nathan Border (Parkes), Crawford family (Trangie), Hanrahan family (Daysdale), Petro Station (Arumpo), Greg and Ben Pollard (Wentworth), Maurice Cluff (Dunedoo).

References

Unkovich M, Herridge D, Peoples M, Cadisch G, Boddey R, Giller K, Alves B and Chalk P (2008) Measuring plant-associated nitrogen fixation in agricultural systems – Part 4. https://www.aciar.gov.au/publication/books-and-manuals/measuring-plant-associated-nitrogen-fixation-agricultural-systems

Swan T, Dunn M, Kirkegaard J, Goward L, Leighton E, Sandral G, Hunt J, Bullock M, Pumpa R, Fiske K, Woodford-Smith A, Reardon D, Barry M and Burns H (2022) What is the N legacy following pulses for subsequent crops and what management options are important to optimise N fixation? 2022 Wagga Wagga GRDC Update.
https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/02/what-is-the-n-legacy-following-pulses-for-subsequent-crops-and-what-management-options-are-important-to-optimise-n-fixation2

Contact details

Rohan Brill
Brill Ag
Ganmain, New South Wales
Mb: 0488 250 489
Email: rohan@brillag.com.au

Date published

February 2026